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PATENT ABSTRACTS OF JAPAN

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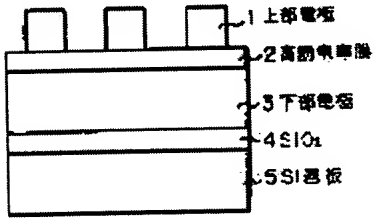
(54) THIN FILM CAPACITOR, ITS MANUFACTURE AND WORKING METHOD OF ELECTRODE



(57)Abstract:
PROBLEM TO BE SOLVED: To realize a thin film capacitor wherein leak current density is small, by forming a first electrode layer which is in contact with at least a high permitivity film of an upper electrode film and has a specified thickness, of ruthenium or ruthenium oxide.
SOLUTION: In a thin film capacitor, BST is used as a high permitivity film 2, and a silicon (Si) substrate 5 has a surface which is SiO2 4 formed by heat treatment, on which substarate 5 the following are formed; Pt as a lower electrode 3, a high permitivity film 2, and single layer Ru as upper electrodes which are 30nm in thickness. An upper electrode film 1 is composed a single layer or a plurality of layers. The first electrode layer which is in contact with at least the high permitivity film 2 is composed of ruthenium(Ru) or ruthenium oxide (RUO2). It is especially

important that the thickness of the layer is less than 50nm and greater than or equal to 5nm. Thereby a thin film capacitor excellent in electric characteristics can be realized.

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CLAIMS

[Claim(s)]
[Claim 1] The thin film capacitor characterized by for the 1st electrode layer of this up electrode layer which touches this high dielectric constant film at least being a ruthenium (Ru) or ruthenium oxide (RuO2), and the thickness of the aforementioned electrode layer being less than 50nm in the thin film capacitor of the structure inserted by the up electrode layer which a high dielectric constant thin film turns into from a lower electrode layer and a monolayer, or two or more layers.
[Claim 2] The manufacture method of the thin film capacitor of the structure inserted by the up electrode layer which is characterized by providing the following, and which a high dielectric constant thin film turns into from a lower electrode layer and a monolayer, or two or more layers The process which forms a ruthenium (Ru) or ruthenium oxide (RuO2) as an electrode layer of this up electrode thin film which touches this high

dielectric constant film at least As 2nd electrode layer which is the best layer of this up electrode thin film, it is oxygen.
[Claim 3] The electrode layer of the above 2nd is the manufacture method of the thin film capacitor according to claim 2 which is either aluminum (aluminum), titanium (Ti) or a titanium nitride (TiN).
[Claim 4] A high dielectric constant film is the manufacture method of the thin film capacitor of the structure inserted by the lower electrode and the up electrode. In the manufacture method by which the process of the dry etching in the atmosphere which contains the oxygen of a ruthenium (Ru) or a ruthenium oxide (RuO2) layer in a lower electrode or an up electrode at least is included The manufacture method of the thin film capacitor characterized by a dry dirty process being an etching process in the electrode structure where the maximum front face of this electrode was formed by either aluminum (aluminum), titanium (Ti) or the titanium nitride (TiN) in the electrode layer of this ruthenium or ruthenium oxide.
[Claim 5] It is the electrode which consisted of a monolayer or two or more layers. to the aforementioned electrode A ruthenium (Ru), Or it sets to the processing method of an electrode of having a dry etching process in the atmosphere in which the layer of ruthenium oxide (RuO2) is contained in, and this ruthenium (Ru) or this ruthenium oxide (RuO2) contains oxygen. The processing method of the electrode characterized by the process of the aforementioned dry etching being an etching process in the electrode structure where the maximum front face of this electrode was formed by either aluminum (aluminum), titanium (Ti) or the titanium nitride (TiN).

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the object for semiconductor devices, and the thin film capacitor for integrated circuits especially about a thin film capacitor, its manufacture method, and the processing method of an electrode.
[0002]
[Description of the Prior Art] SrTiO3 which was excellent in dielectric characteristics, insulation, and chemical stability in order to apply to the capacity film for next-generation high-density DRAM of 1 or more Gbits, TiO (Ba, Sr)3 (henceforth BST), and TiO (Pb, Zr)3 etc. -- research and development of a perovskite type oxide dielectric thin film are done Simultaneously, in order to depend in the electrode material and process

strongly, examination of an electrode material is also important for the electrical property of a dielectric thin film.

[0003] Ru or RuO2 It has the feature that the processability is good, and the application as an electrode material of a BST film is considered. About the thin film capacitor using Ru as an electrode material, and its manufacture method, A. YUUKI etc. is reported in detail to a technical digest, 115-118 pages and this technical digest, and 903-906 pages by Y. rock shell ochre etc. in International electron device "meeting IEDM"" 1995, respectively.

[0004] The publication of the thickness of Ru does not have an up electrode in the thin film capacitor using Ru monolayer, using barium-titanate strontium (Ba, Sr) (it omitting below TiO3; BST) as a conventional high dielectric constant film. Moreover, by the manufacture method of the conventional thin film capacitor, micro processing of Ru is SiO2. It is carried out by the reactive-ion-etching method using the mask.

[0005]

[Problem(s) to be Solved by the Invention] Generally, in order to make the capacity of a thin film capacitor increase, it is required to make thin thickness of the high dielectric constant film which is an electrode spacing, i.e., a capacity film. When next-generation high-density DRAM of 1 or more Gbits is considered especially, even if it uses high dielectric constant films, such as BST, about 20-30nm needs to be ultra-thin-film-ized. However, ultra-thin film-ization of such a high dielectric constant film has the problem of increasing the leakage current of a thin film capacitor. Generally, the area of a capacitor is taken into consideration, it is such leakage-current density of a thin film capacitor at the 1V impression time, and less than [1x10-8Acm-2] is needed.

[0006] In the conventional thin film capacitor, when the thickness of BST was 25nm, the leakage-current density in the time of 1V impression is abbreviation 4x10-8Acm-2, and had the problem that the current density demanded was not reached.

[0007] On the other hand, it is SiO2 on Ru electrode in the case of processing of the up electrode Ru by the manufacture method of the conventional thin film capacitor. Membranes are formed, a resist is processed with the photolithography technology which applies a resist and is generally used, and it is SiO2. Patterning was carried out and Ru was processed. Thus, at a Prior art, it is SiO2. The process of membrane formation and removal entered and there was a problem in respect of a throughput.

[0008] Moreover, it is SiO2 although Ru must be processed in 0.1-0.2-micron size in case Ru is used for the lower electrode of next-generation high-density DRAM of 1 or more Gbits. When a mask was used, while there was a problem in respect of a throughput by the above-mentioned reason, the problem was in the processing configuration. This is SiO2. It is amorphous and is SiO2 to Ru dry etching. By a shoulder **********ing, it is SiO2. For mask area to become small and it is hard to process processed Ru perpendicularly.

[0009] The purpose of this invention is to offer a thin film capacitor with small leakage-current density. Moreover, a throughput is high, and since it is a process in low temperature, it is in offering the manufacture method of a thin film capacitor of not degrading the circuit property of a semiconductor, and it is in offering the manufacture method of the thin film capacitor which processing of further super-large scale integration can attain in the target processing configuration, and the processing method of an electrode.

[0010]
[Means for Solving the Problem] The aforementioned purpose is attained by the following meanses. That is, this invention proposes the thin film capacitor characterized by for the 1st electrode layer of this up electrode layer which touches this high dielectric constant film at least being a ruthenium (Ru) or ruthenium oxide (RuO2), and the thickness of the aforementioned electrode layer being less than 50nm in the thin film capacitor of the structure inserted by the up electrode layer which a high dielectric constant thin film turns into from a lower electrode layer and a monolayer, or two or more layers.
[0011] Moreover, a high dielectric constant thin film sets this invention to the manufacture method of the thin film capacitor of the structure inserted by the up electrode layer which consists of a lower electrode layer and a monolayer, or two or more layers. The process which forms a ruthenium (Ru) or ruthenium oxide (RuO2) as an electrode layer of this up electrode thin film which touches this high dielectric constant film at least, [whether as 2nd electrode layer which is the best layer of this up electrode thin film, the dry etching in the atmosphere containing oxygen **********s, and] Or it is what proposes the manufacture method of the thin film capacitor characterized by including at least the process which forms the conductive electrode material whose etch rate of dry etching is 1/10 or less [of the etch rate of the 1st electrode layer]. It includes that the electrode layer of the above 2nd is either aluminum (aluminum), titanium (Ti) or a titanium nitride (TiN).
[0012] Moreover, this invention is the manufacture method of the thin film capacitor of the structure where the high dielectric constant film was inserted by the lower electrode and the up electrode. In the manufacture method by which the process of the dry etching in the atmosphere which contains the oxygen of a ruthenium (Ru) or a ruthenium oxide (RuO2) layer in a lower electrode or an up electrode at least is included The electrode layer of this ruthenium or ruthenium oxide a dry dirty process It is what proposes the manufacture method of the thin film capacitor characterized by being an etching process in the electrode structure where the maximum front face of this electrode was formed by either aluminum (aluminum), titanium (Ti) or the titanium nitride (TiN). this invention is the electrode which consisted of a monolayer or two or more layers. to the aforementioned electrode Furthermore, a ruthenium (Ru), Or it sets to the processing method of an electrode of having a dry etching process in the atmosphere in which the layer of ruthenium oxide (RuO2) is contained in, and this ruthenium (Ru) or this ruthenium oxide (RuO2) contains oxygen. The processing method of the electrode characterized by the process of the aforementioned dry etching being an etching process in the electrode structure where the maximum front face of this electrode was formed by either aluminum (aluminum), titanium (Ti) or the titanium nitride (TiN) is proposed.
[0013]
[Embodiments of the Invention] Hereafter, this invention is explained still in detail.
[0014] this invention person etc. uses BST as a high dielectric constant film, and is Ru and RuO2 as an up electrode. It used, respectively, the thin film capacitor was formed, and the leakage-current property was investigated. A lower electrode is platinum (Pt). Consequently, it found out that a leakage current decreased by setting thickness of an up electrode to 100nm or less. Simultaneously, thickness found out that the downward tendency of a leakage current was remarkable by less than 50nm. When thickness of an

up electrode was based on 200nm, thickness decreased to 10 by about 1/by 50nm, and thickness decreased to 15 by about 1/in 30nm. Although the detail of this reason is unknown, reduction of the damage to the BST film at the time of up electrode formation and reduction of stress can be considered.

[0015] this invention person etc. is Ru and RuO2 as an up electrode layer which touches BST, using BST as a high dielectric constant film. aluminum, Ti, and TiN were formed in the upper part, respectively. It is Ru and RuO2, applying a resist besides, processing a resist with the usual photolithography technology, and using it as a mask. Dry etching of each upper conductive electrode was carried out. Chlorine gas was used at this time. Continuously, it is Ru and RuO2 in the atmosphere containing oxygen. When dry etching is carried out, it is Ru and RuO2. Although etching advances with etching also in a resist, it is Ru and RuO2. The upper conductive electrode is not made to ********** but is Ru and RuO2. It turns out that it is processible. The resist which remained is O2. It was easily removable by ashing. Simultaneously, it is Ru and RuO2. When the upper conductive electrode was usable as an up electrode as it is and it was unnecessary, the thing possible dirtily in a businesslike manner was also continuously checked after resist removal. At this technique, it is SiO2. It became clear that the process of formation and removal is unnecessary, it is very simple, and a throughput is high. Moreover, it is Ru of the 1st electrode, and RuO2, without making the 2nd electrode **********, even if the etch rate of dry etching uses 1/10 or less electrode material of the etch rate of the 1st electrode layer as 2nd electrode layer. It turns out that it is processible.

[0016] the same -- especially -- Ru and RuO2 the time of it being overly detailed-alike and processing it -- Ru and RuO2 Although aluminum, Ti, or TiN was formed in the upper surface of an electrode and dry etching processing was performed at the same process as the above, it was possible to have not carried out the shoulder collapse of aluminum, Ti, or the TiN at all, but to have processed Ru and RuO2 into a perpendicular mostly.

[0017] Furthermore, this invention is explained with reference to a drawing.

[0018] Drawing 1 is the cross section showing an example of the thin film capacitor of this invention. The thin film capacitor of this invention comes to prepare the structure where the high dielectric constant thin film 2 was inserted by the lower electrode 3 and the up electrode layer 1 on the SiO2 silicon (Si) substrate 5 in which the substrate front face was formed by thermal oxidation and which has 4, as shown in drawing 1 .

[0019] as the high dielectric constant thin film 2 -- SrTiO3, TiO (Ba, Sr)3 (BST), BaTiO3, TiO (Pb, Zr)3, and SrBi2 Ta 2O9 etc. -- it is mentioned and the range of thickness of 15-200nm is desirable

[0020] It consists of a monolayer or two or more layers, and the 1st electrode layer which touches a high dielectric constant film at least consists of a ruthenium (Ru) or ruthenium oxide (RuO2), and, as for the up electrode layer 1, it is important that the thickness is especially less than 50nm 5nm or more.

[0021] Since the leakage current of a thin film capacitor will be increased if thickness exceeds 50nm, it is [a problem (local discontinuity in a field) from which a homogeneous membrane is hard to be obtained in less than 5nm] preferably and is not desirable. Moreover, when the up electrode layer 1 consists of two or more layers, as the 2nd electrode layer, aluminum (aluminum), titanium (Ti), or a titanium nitride (TiN) is used preferably.

[0022] Moreover, Pt, Ru, RuO2, Ir, and IrO2 grade are mentioned as a lower electrode 3, and the range of thickness of 5-500nm is desirable.
[0023] Each aforementioned film can be formed by methods, such as the DC magnetron-sputtering method, the RF magnetron-sputtering method, an efficient consumer response spatter, and a vapor growth.
[0024]
[Example] An example explains this invention still more concretely below.
[0025] (Example 1) The example of this invention is explained hereafter, referring to drawing 1 . Drawing 1 is the cross section of the thin film capacitor in connection with an example 1. It has the structure where 30nm of Ru of a monolayer was formed as Pt, the high dielectric constant film 2, and an up electrode as a lower electrode 3 on the SiO2 silicon (Si) substrate 5 in which the substrate front face was formed by thermal oxidation and which has 4, using BST as a high dielectric constant film 2. In this example, BST thickness is 30nm and all the films were formed by the DC magnetron sputtering method. The configuration of an up electrode is the round shape of 0.2mmphi. As a result of measuring an electrical property, the dielectric constant was 290 and the leakage-current density J was 8x10-9Acm-2. in order to investigate the effect of thin-film-izing of Ru of this invention, as a result of changing the thickness of Ru which is an up electrode to 200nm and investigating it to the same sample, by 200nm, J is 1.5x10-8Acm-2 in 8x10-8Acm-2,100nm, and the effect which is this invention was checked The dielectric constant bases on the thickness of an up electrode and was fixed.
[0026] (Example 2) It has structure which is the electrode by which Ru (30nm) and aluminum (100nm) were carried out as a lower electrode 3 like the example 1 on the SiO2 silicon (Si) substrate 5 in which the substrate front face was formed by thermal oxidation, and which has 4, using BST as a high dielectric constant film 2, and the laminating was carried out to the order of a lower shell as Pt, the high dielectric constant film 2, and an up electrode. In this example, BST thickness is 30nm and all the films were formed by the DC magnetron sputtering method. The configuration of an up electrode is the round shape of 0.2mmphi. As a result of measuring an electrical property, the dielectric constant was 290 and the leakage-current density J was 8x10-9Acm-2. In order to investigate the effect of this invention, the same with having carried out in the example 1, the thickness of aluminum of an up electrode layer was set constant, and the effect of thin-film-izing of Ru was investigated. It is completely the same as that of an example 1, and a result is a book.
[0027] (Example 3) By this example, the example which used TiN as Ru and 2nd electrode layer as 1st electrode layer of BST and the up electrode 1 as RuO2 and a high dielectric constant film 2 as a lower electrode 3 is explained, referring to drawing 2 .
[0028] On the SiO2 silicon (Si) substrate 5 which was formed by thermal oxidation and which has 4, the substrate front face formed the lower electrode 3 (RuO2), the high dielectric constant film 2 (BST), the 1st electrode layer 6 of the up electrode 1 (Ru), and the 2nd electrode layer 7 (TiN) by the DC magnetron-sputtering method one by one. 30nm and the 2nd electrode layer set thickness to 200nm, and 30nm and the 1st electrode layer set [the lower electrode] BST to 70nm. Continuously, the resist 8 was applied and the substrate shown in drawing 2 (a) was obtained. With the lithography technology by the usual i line, it exposed, the resist was processed, and drawing 2 (b) was formed. It is TiN which this substrate is put into a dry etching system, and is the 2nd electrode layer 7

first Cl2 It **********ed by plasma gas. At this time, the chamber pressures of an etching system were 15mTorr(s), and plasma power was 50W. Ru which is the 1st electrode layer 6 continuously -- O2 Cl2 mixed gas (Cl2 is 10%) -- using -- etching -- the bottom The chamber pressures at this time are 20mTorr(s), and plasma power is 100W. Although most resists disappeared Ru in dry etching, in order to remove the resist which remained, ashing by oxygen plasma removed. Consequently, the thin film capacitor into which the up electrode as shown in drawing 2 (c) was processed was obtained. Similarly, although inquired by the same manufacture method, using aluminum or Ti as 2nd electrode layer, the completely same thin film capacitor was obtained. The electrical property of this capacitor showed the same good property as examples 1 and 2.

[0029] At this process, it is SiO2 as a mask. It does not form but is a book.

[0030] Cl2 although the 2nd electrode layer was not removed but it was used as it is as an electrode in the above-mentioned example, after carrying out ashing removal of the resist Although the thin film capacitor from which the 2nd electrode layer 7 (TiN) was removed by the dry etching by plasma gas was also made, the case where it does not remove, and the electrical property were the same.

[0031] (Example 4) this example explains Ru which is a lower electrode using drawing 3 about the example which carried out micro processing very much.

[0032] On the SiO2 silicon (Si) substrate 5 in which the substrate front face was formed by thermal oxidation and which has 4, Ru9 was formed by 300nm and TiN10 was formed by 100nm and the DC magnetron-sputtering method. The substrate which drawing 3 (a) Comes to apply the chemistry amplification resist 8 to this substrate was formed. By electron beam exposure, the processing size 0.2 micron x0.5 micron pattern was formed, and the substrate which drawing 3 (b) Comes to process a resist 8 was formed. It is Cl2 about TiN10, putting this substrate into a dry etching system, and using a resist 8 as a mask. Etching by plasma was performed. The pressures of the etching system at this time are 15mTorr(s), and plasma power is 50W. continuing -- Ru 9O2 Cl2 mixed gas (Cl2 is 10%) -- using -- etching -- the bottom The chamber pressures at this time are 20mTorr(s), and plasma power is 100W. The resist disappeared Ru in dry etching. Continuously, it is Cl2 about TiN10. Plasma etching was carried out, it removed and the substrate shown in drawing 3 (c) was obtained. The pressures of the etching system at this time are 15mTorr(s), and plasma power is 50W.

[0033] As a result of observing the obtained substrate with an electron microscope, it checked that processing was made as a design size. Moreover, the same result was obtained although experimented also about the case where Ti or aluminum is used for a change of TiN.

[0034] in the above-mentioned example, although BST was used as a high dielectric constant film, this invention is limited to this material -- not having -- a strontium titanate (SrTiO3), a barium titanate (BaTiO3), and TiO(Pb, Zr) 3 SrBi2 Ta 2O9 etc. -- other high dielectric films are sufficient

[0035] Although the DC magnetron-sputtering method was used as the membrane formation method of an electrode and a dielectric in the above-mentioned example, this invention may not be limited to this but the RF magnetron-sputtering method, an efficient consumer response spatter, and ********** are sufficient as it.

[0036] Although Ru was used in the above-mentioned example, this invention may not be limited to this material, but RuO2 is sufficient as it.

[0037]
[Effect of the Invention] As mentioned above, as explained, according to the thin film capacitor of this invention, it is effective in leakage-current density being small and excelling in an electrical property. Moreover, according to the manufacture method of the thin film capacitor of this invention, a throughput is high, and since it is a process in low temperature, it is effective in the ability of processing of further super-large scale integration which does not degrade the circuit property of a semiconductor to attain in the target processing configuration.

[Translation done.]

TECHNICAL FIELD

[The technical field to which invention belongs] this invention relates to the object for semiconductor devices, and the thin film capacitor for integrated circuits especially about a thin film capacitor, its manufacture method, and the processing method of an electrode.
[0002]

[Translation done.]

PRIOR ART

[Description of the Prior Art] SrTiO3 which was excellent in dielectric characteristics, insulation, and chemical stability in order to apply to the capacity film for next-generation high-density DRAM of 1 or more Gbits, TiO (Ba, Sr)3 (henceforth BST), and TiO (Pb, Zr)3 etc. -- research and development of a perovskite type oxide dielectric thin film are done Simultaneously, in order to depend in the electrode material and process strongly, examination of an electrode material is also important for the electrical property of a dielectric thin film.
[0003] Ru or RuO2 It has the feature that the processability is good, and the application as an electrode material of a BST film is considered. About the thin film capacitor using Ru as an electrode material, and its manufacture method, A. YUUKI etc. is reported in detail to a technical digest, 115-118 pages and this technical digest, and 903-906 pages by Y. rock shell ochre etc. in International electron device "meeting IEDM"" 1995, respectively.
[0004] The publication of the thickness of Ru does not have an up electrode in the thin film capacitor using Ru monolayer, using barium-titanate strontium (Ba, Sr) (it omitting below TiO3; BST) as a conventional high dielectric constant film. Moreover, by the manufacture method of the conventional thin film capacitor, micro processing of Ru is SiO2. It is carried out by the reactive-ion-etching method using the mask.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention] As mentioned above, as explained, according to the thin film capacitor of this invention, it is effective in leakage-current density being small and excelling in an electrical property. Moreover, according to the manufacture method of the thin film capacitor of this invention, a throughput is high, and since it is a process in low temperature, it is effective in the ability of processing of further super-large scale integration which does not degrade the circuit property of a semiconductor to attain in the target processing configuration.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] Generally, in order to make the capacity of a thin film capacitor increase, it is required to make thin thickness of the high dielectric constant film which is an electrode spacing, i.e., a capacity film. When next-generation high-density DRAM of 1 or more Gbits is considered especially, even if it uses high dielectric constant films, such as BST, about 20-30nm needs to be ultra-thin-film-ized. However, ultra-thin film-ization of such a high dielectric constant film has the problem of increasing the leakage current of a thin film capacitor. Generally, the area of a capacitor is taken into consideration, it is such leakage-current density of a thin film capacitor at the 1V impression time, and less than [1x10-8Acm-2] is needed.

[0006] In the conventional thin film capacitor, when the thickness of BST was 25nm, the leakage-current density in the time of 1V impression is abbreviation 4x10-8Acm-2, and had the problem that the current density demanded was not reached.

[0007] On the other hand, it is SiO2 on Ru electrode in the case of processing of the up electrode Ru by the manufacture method of the conventional thin film capacitor. Membranes are formed, a resist is processed with the photolithography technology which applies a resist and is generally used, and it is SiO2. Patterning was carried out and Ru was processed. Thus, at a Prior art, it is SiO2. The process of membrane formation and removal entered and there was a problem in respect of a throughput.

[0008] Moreover, it is SiO2 although Ru must be processed in 0.1-0.2-micron size in case Ru is used for the lower electrode of next-generation high-density DRAM of 1 or more Gbits. When a mask was used, while there was a problem in respect of a throughput by the above-mentioned reason, the problem was in the processing configuration. This is SiO2. It is amorphous and is SiO2 to Ru dry etching. By a shoulder **********ing, it is SiO2. For mask area to become small and it is hard to process processed Ru perpendicularly.

[0009] The purpose of this invention is to offer a thin film capacitor with small leakage-

current density. Moreover, a throughput is high, and since it is a process in low temperature, it is in offering the manufacture method of a thin film capacitor of not degrading the circuit property of a semiconductor, and it is in offering the manufacture method of the thin film capacitor which processing of further super-large scale integration can attain in the target processing configuration, and the processing method of an electrode.

[Translation done.]

MEANS

[Means for Solving the Problem] The aforementioned purpose is attained by the following meanses. That is, this invention proposes the thin film capacitor characterized by for the 1st electrode layer of this up electrode layer which touches this high dielectric constant film at least being a ruthenium (Ru) or ruthenium oxide (RuO2), and the thickness of the aforementioned electrode layer being less than 50nm in the thin film capacitor of the structure inserted by the up electrode layer which a high dielectric constant thin film turns into from a lower electrode layer and a monolayer, or two or more layers.

[0011] Moreover, a high dielectric constant thin film sets this invention to the manufacture method of the thin film capacitor of the structure inserted by the up electrode layer which consists of a lower electrode layer and a monolayer, or two or more layers. The process which forms a ruthenium (Ru) or ruthenium oxide (RuO2) as an electrode layer of this up electrode thin film which touches this high dielectric constant film at least, [whether as 2nd electrode layer which is the best layer of this up electrode thin film, the dry etching in the atmosphere containing oxygen **********s, and] Or it is what proposes the manufacture method of the thin film capacitor characterized by including at least the process which forms the conductive electrode material whose etch rate of dry etching is 1/10 or less [of the etch rate of the 1st electrode layer]. It includes that the electrode layer of the above 2nd is either aluminum (aluminum), titanium (Ti) or a titanium nitride (TiN).

[0012] Moreover, this invention is the manufacture method of the thin film capacitor of the structure where the high dielectric constant film was inserted by the lower electrode and the up electrode. In the manufacture method by which the process of the dry etching in the atmosphere which contains the oxygen of a ruthenium (Ru) or a ruthenium oxide (RuO2) layer in a lower electrode or an up electrode at least is included The electrode layer of this ruthenium or ruthenium oxide a dry dirty process It is what proposes the manufacture method of the thin film capacitor characterized by being an etching process in the electrode structure where the maximum front face of this electrode was formed by either aluminum (aluminum), titanium (Ti) or the titanium nitride (TiN). this invention is the electrode which consisted of a monolayer or two or more layers. to the aforementioned electrode Furthermore, a ruthenium (Ru), Or it sets to the processing method of an electrode of having a dry etching process in the atmosphere in which the layer of ruthenium oxide (RuO2) is contained in, and this ruthenium (Ru) or this

ruthenium oxide (RuO2) contains oxygen. The processing method of the electrode characterized by the process of the aforementioned dry etching being an etching process in the electrode structure where the maximum front face of this electrode was formed by either aluminum (aluminum), titanium (Ti) or the titanium nitride (TiN) is proposed.
[0013]
[Embodiments of the Invention] Hereafter, this invention is explained still in detail.
[0014] this invention person etc. uses BST as a high dielectric constant film, and is Ru and RuO2 as an up electrode. It used, respectively, the thin film capacitor was formed, and the leakage-current property was investigated. A lower electrode is platinum (Pt). Consequently, it found out that a leakage current decreased by setting thickness of an up electrode to 100nm or less. Simultaneously, thickness found out that the downward tendency of a leakage current was remarkable by less than 50nm. When thickness of an up electrode was based on 200nm, thickness decreased to 10 by about 1/by 50nm, and thickness decreased to 15 by about 1/in 30nm. Although the detail of this reason is unknown, reduction of the damage to the BST film at the time of up electrode formation and reduction of stress can be considered.
[0015] this invention person etc. is Ru and RuO2 as an up electrode layer which touches BST, using BST as a high dielectric constant film. aluminum, Ti, and TiN were formed in the upper part, respectively. It is Ru and RuO2, applying a resist besides, processing a resist with the usual photolithography technology, and using it as a mask. Dry etching of each upper conductive electrode was carried out. Chlorine gas was used at this time. Continuously, it is Ru and RuO2 in the atmosphere containing oxygen. When dry etching is carried out, it is Ru and RuO2. Although etching advances with etching also in a resist, it is Ru and RuO2. The upper conductive electrode is not made to ********** but is Ru and RuO2. It turns out that it is processible. The resist which remained is O2. It was easily removable by ashing. Simultaneously, it is Ru and RuO2. When the upper conductive electrode was usable as an up electrode as it is and it was unnecessàry, the thing possible dirtily in a businesslike manner was also continuously checked after resist removal. At this technique, it is SiO2. It became clear that the process of formation and removal is unnecessary, it is very simple, and a throughput is high. Moreover, it is Ru of the 1st electrode, and RuO2, without making the 2nd electrode **********, even if the etch rate of dry etching uses 1/10 or less electrode material of the etch rate of the 1st electrode layer as 2nd electrode layer. It turns out that it is processible.
[0016] the same -- especially -- Ru and RuO2 the time of it being overly detailed-alike and processing it -- Ru and RuO2 Although aluminum, Ti, or TiN was formed in the upper surface of an electrode and dry etching processing was performed at the same process as the above, it was possible to have not carried out the shoulder collapse of aluminum, Ti, or the TiN at all, but to have processed Ru and RuO2 into a perpendicular mostly.
[0017] Furthermore, this invention is explained with reference to a drawing.
[0018] Drawing 1 is the cross section showing an example of the thin film capacitor of this invention. The thin film capacitor of this invention comes to prepare the structure where the high dielectric constant thin film 2 was inserted by the lower electrode 3 and the up electrode layer 1 on the SiO2 silicon (Si) substrate 5 in which the substrate front face was formed by thermal oxidation and which has 4, as shown in drawing 1.
[0019] as the high dielectric constant thin film 2 -- SrTiO3, TiO (Ba, Sr)3 (BST),

BaTiO3, TiO (Pb, Zr)3, and SrBi2 Ta 2O9 etc. -- it is mentioned and the range of thickness of 15-200nm is desirable

[0020] It consists of a monolayer or two or more layers, and the 1st electrode layer which touches a high dielectric constant film at least consists of a ruthenium (Ru) or ruthenium oxide (RuO2), and, as for the up electrode layer 1, it is important that the thickness is especially less than 50nm 5nm or more.

[0021] Since the leakage current of a thin film capacitor will be increased if thickness exceeds 50nm, it is [a problem (local discontinuity in a field) from which a homogeneous membrane is hard to be obtained in less than 5nm] preferably and is not desirable. Moreover, when the up electrode layer 1 consists of two or more layers, as the 2nd electrode layer, aluminum (aluminum), titanium (Ti), or a titanium nitride (TiN) is used preferably.

[0022] Moreover, Pt, Ru, RuO2, Ir, and IrO2 grade are mentioned as a lower electrode 3, and the range of thickness of 5-500nm is desirable.

[0023] Each aforementioned film can be formed by methods, such as the DC magnetron-sputtering method, the RF magnetron-sputtering method, an efficient consumer response spatter, and a vapor growth.

[Translation done.]

EXAMPLE

[Example] An example explains this invention still more concretely below.

[0025] (Example 1) The example of this invention is explained hereafter, referring to drawing 1 . Drawing 1 is the cross section of the thin film capacitor in connection with an example 1. It has the structure where 30nm of Ru of a monolayer was formed as Pt, the high dielectric constant film 2, and an up electrode as a lower electrode 3 on the SiO2 silicon (Si) substrate 5 in which the substrate front face was formed by thermal oxidation and which has 4, using BST as a high dielectric constant film 2. In this example, BST thickness is 30nm and all the films were formed by the DC magnetron sputtering method. The configuration of an up electrode is the round shape of 0.2mmphi. As a result of measuring an electrical property, the dielectric constant was 290 and the leakage-current density J was 8x10-9Acm-2. in order to investigate the effect of thin-film-izing of Ru of this invention, as a result of changing the thickness of Ru which is an up electrode to 200nm and investigating it to the same sample, by 200nm, J is 1.5x10-8Acm-2 in 8x10-8Acm-2,100nm, and the effect which is this invention was checked The dielectric constant bases on the thickness of an up electrode and was fixed.

[0026] (Example 2) It has structure which is the electrode by which Ru (30nm) and aluminum (100nm) were carried out as a lower electrode 3 like the example 1 on the SiO2 silicon (Si) substrate 5 in which the substrate front face was formed by thermal oxidation, and which has 4, using BST as a high dielectric constant film 2, and the laminating was carried out to the order of a lower shell as Pt, the high dielectric constant film 2, and an up electrode. In this example, BST thickness is 30nm and all the films were formed by the DC magnetron sputtering method. The configuration of an up electrode is the round shape of 0.2mmphi. As a result of measuring an electrical property, the dielectric constant was 290 and the leakage-current density J was 8x10-9Acm-2. In

order to investigate the effect of this invention, the same with having carried out in the example 1, the thickness of aluminum of an up electrode layer was set constant, and the effect of thin-film-izing of Ru was investigated. It is completely the same as that of an example 1, and a result is a book.

[0027] (Example 3) By this example, the example which used TiN as Ru and 2nd electrode layer as 1st electrode layer of BST and the up electrode 1 as RuO2 and a high dielectric constant film 2 as a lower electrode 3 is explained, referring to drawing 2 .

[0028] On the SiO2 silicon (Si) substrate 5 which was formed by thermal oxidation and which has 4, the substrate front face formed the lower electrode 3 (RuO2), the high dielectric constant film 2 (BST), the 1st electrode layer 6 of the up electrode 1 (Ru), and the 2nd electrode layer 7 (TiN) by the DC magnetron-sputtering method one by one. 30nm and the 2nd electrode layer set thickness to 200nm, and 30nm and the 1st electrode layer set [the lower electrode] BST to 70nm. Continuously, the resist 8 was applied and the substrate shown in drawing 2 (a) was obtained. With the lithography technology by the usual i line, it exposed, the resist was processed, and drawing 2 (b) was formed. It is TiN which this substrate is put into a dry etching system, and is the 2nd electrode layer 7 first Cl2 It **********ed by plasma gas. At this time, the chamber pressures of an etching system were 15mTorr(s), and plasma power was 50W. Ru which is the 1st electrode layer 6 continuously -- O2 Cl2 mixed gas (Cl2 is 10%) -- using -- etching -- the bottom The chamber pressures at this time are 20mTorr(s), and plasma power is 100W. Although most resists disappeared Ru in dry etching, in order to remove the resist which remained, ashing by oxygen plasma removed. Consequently, the thin film capacitor into which the up electrode as shown in drawing 2 (c) was processed was obtained. Similarly, although inquired by the same manufacture method, using aluminum or Ti as 2nd electrode layer, the completely same thin film capacitor was obtained. The electrical property of this capacitor showed the same good property as examples 1 and 2.

[0029] At this process, it is SiO2 as a mask. It does not form but is a book.

[0030] Cl2 although the 2nd electrode layer was not removed but it was used as it is as an electrode in the above-mentioned example, after carrying out ashing removal of the resist Although the thin film capacitor from which the 2nd electrode layer 7 (TiN) was removed by the dry etching by plasma gas was also made, the case where it does not remove, and the electrical property were the same.

[0031] (Example 4) this example explains Ru which is a lower electrode using drawing 3 about the example which carried out micro processing very much.

[0032] On the SiO2 silicon (Si) substrate 5 in which the substrate front face was formed by thermal oxidation and which has 4, Ru9 was formed by 300nm and TiN10 was formed by 100nm and the DC magnetron-sputtering method. The substrate which drawing 3 (a) Comes to apply the chemistry amplification resist 8 to this substrate was formed. By electron beam exposure, the processing size 0.2 micron x0.5 micron pattern was formed, and the substrate which drawing 3 (b) Comes to process a resist 8 was formed. It is Cl2 about TiN10, putting this substrate into a dry etching system, and using a resist 8 as a mask. Etching by plasma was performed. The pressures of the etching system at this time are 15mTorr(s), and plasma power is 50W. continuing -- Ru 9O2 Cl2 mixed gas (Cl2 is 10%) -- using -- etching -- the bottom The chamber pressures at this time are 20mTorr(s), and plasma power is 100W. The resist disappeared Ru in dry etching. Continuously, it is Cl2 about TiN10. Plasma etching was carried out, it removed and the substrate shown in

drawing 3 (c) was obtained. The pressures of the etching system at this time are 15mTorr(s), and plasma power is 50W.

[0033] As a result of observing the obtained substrate with an electron microscope, it checked that processing was made as a design size. Moreover, the same result was obtained although experimented also about the case where Ti or aluminum is used for a change of TiN.

[0034] in the above-mentioned example, although BST was used as a high dielectric constant film, this invention is limited to this material -- not having -- a strontium titanate (SrTiO3), a barium titanate (BaTiO3), and TiO(Pb, Zr) 3 SrBi2 Ta 2O9 etc. -- other high dielectric films are sufficient

[0035] Although the DC magnetron-sputtering method was used as the membrane formation method of an electrode and a dielectric in the above-mentioned example, this invention may not be limited to this but the RF magnetron-sputtering method, an efficient consumer response spatter, and ********** are sufficient as it.

[0036] Although Ru was used in the above-mentioned example, this invention may not be limited to this material, but RuO2 is sufficient as it.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the cross section of the thin film capacitor in which one example of this invention is shown.

[Drawing 2] Drawing 2 (a) - (c) is the manufacturing process view of the thin film capacitor in which one example of this invention is shown.

[Drawing 3] Drawing 3 (a) - (c) is the manufacturing process view of the thin film capacitor in which one example of this invention is shown.

[Description of Notations]

1 Up Electrode
2 High Dielectric Constant Film
3 Lower Electrode
4 SiO2
5 Si Substrate
6 1st Electrode Layer
7 2nd Electrode Layer
8 Resist
9 Ru
10 TiN

[Translation done.]

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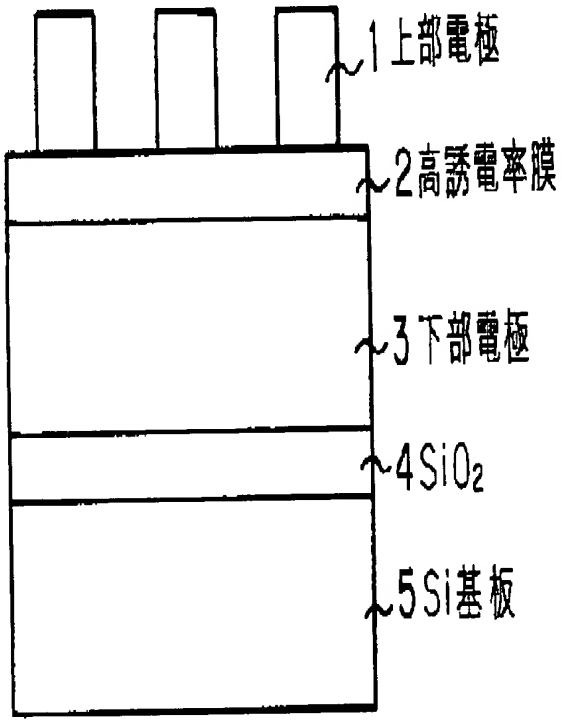
(54)【発明の名称】　薄膜キャパシタ、その製造方法および電極の加工方法

(57)【要約】

【課題】　リーク電流密度が小さく、電気的特性の優れた薄膜キャパシタ、その製造方法及び電極の加工方法を提供する。

【解決手段】　高誘電率薄膜２が下部電極膜３及び単層或は複数層からなる上部電極膜１で挟まれた構造の薄膜キャパシタであって、上部電極１の少なくとも高誘電率膜２に接する電極層がＲｕ或はRuO_2であり、前記電極層の膜厚が５０ｎｍ未満であることを特徴とする。



【特許請求の範囲】

【請求項１】　高誘電率薄膜が、下部電極膜、及び単層或は複数層からなる上部電極膜で挟まれた構造の薄膜キャパシタにおいて、該上部電極膜の少なくとも該高誘電率膜に接する第１の電極層がルテニウム（Ｒｕ）、或は酸化ルテニウム（RuO_2）であり、かつ前記電極層の膜厚が５０ｎｍ未満であることを特徴とする薄膜キャパシタ。

【請求項２】　高誘電率薄膜が、下部電極膜、及び単層或は複数層からなる上部電極膜で挟まれた構造の薄膜キャパシタの製造方法において、該上部電極薄膜の少なくとも該高誘電率膜に接する電極層としてルテニウム（Ｒｕ）、或は酸化ルテニウム（RuO_2）を形成する工程と、該上部電極薄膜の最上層である第２の電極層として、酸素を含む雰囲気でのドライエッチングによりエッチングされないか、或はドライエッチングのエッチング速度が第１の電極層のエッチング速度の１／１０以下である導電性電極材料を形成する工程を少なくとも含むことを特徴とする薄膜キャパシタの製造方法。

【請求項３】　前記第２の電極層はアルミニウム（Ａｌ）、チタン（Ｔｉ）、或は窒化チタン（ＴｉＮ）のいずれかである請求項２記載の薄膜キャパシタの製造方法。

【請求項４】　高誘電率膜が、下部電極、及び上部電極で挟まれた構造の薄膜キャパシタの製造方法であり、少なくとも下部電極、或は上部電極にルテニウム（Ｒｕ）、或は酸化ルテニウム（RuO_2）層の酸素を含む雰囲気でのドライエッチングの工程が含まれる製造方法において、該ルテニウム、或は酸化ルテニウムの電極層をドライエッチの工程が、該電極の最表面がアルミニウム（Ａｌ）、チタン（Ｔｉ）、或は窒化チタン（ＴｉＮ）のいずれかで形成された電極構造でのエッチング工程であることを特徴とする薄膜キャパシタの製造方法。

【請求項５】　単層、或は複数層で構成された電極で、かつ前記電極にルテニウム（Ｒｕ）、或は酸化ルテニウム（RuO_2）の層が含まれ、かつ該ルテニウム（Ｒｕ）、或は該酸化ルテニウム（RuO_2）が酸素を含む雰囲気でのドライエッチング工程を有する電極の加工方法において、前記ドライエッチングの工程が、該電極の最表面がアルミニウム（Ａｌ）、チタン（Ｔｉ）、或は窒化チタン（ＴｉＮ）のいずれかで形成された電極構造でのエッチング工程であることを特徴とする電極の加工方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、薄膜キャパシタ、その製造方法および電極の加工方法に関し、特に半導体装置用、集積回路用の薄膜キャパシタに関するものである。

【０００２】

【従来の技術】１Ｇｂｉｔ以上の次世代高密度ＤＲＡＭ用容量膜に適用するために、誘電特性、絶縁性、化学的安定性に優れた$SrTiO_3$、（Ｂａ，Ｓｒ）TiO_3（以下、ＢＳＴという）、（Ｐｂ，Ｚｒ）TiO_3等のペロブスカイト型酸化物誘電体薄膜の研究開発が行われている。同時に、誘電体薄膜の電気特性はその電極材料やプロセスに強く依存するため、電極材料の検討も重要である。

【０００３】Ｒｕ、或はRuO_2はその加工性が良好であるという特徴を有し、ＢＳＴ膜の電極材料としての適用が検討されている。電極材料としてＲｕを用いた薄膜キャパシタおよびその製造方法については、インターナショナル・エレクトロン・デバイス・ミーティング『ＩＥＤＭ』“１９９５年、テクニカルダイジェスト、１１５～１１８頁、及び同テクニカルダイジェスト、９０３～９０６頁に、それぞれＡ．ユウキ等、及びＹ．ニシオカ等によって詳細に報告されている。

【０００４】従来の高誘電率膜としてチタン酸バリウムストロンチウム（（Ｂａ，Ｓｒ）TiO_3；以下ＢＳＴと略す）を用い、上部電極がＲｕ単層を用いた薄膜キャパシタには、Ｒｕの膜厚の記載はない。また、従来の薄膜キャパシタの製造方法では、Ｒｕの微細加工は、SiO_2マスクを用いて反応性イオンエッチング法により行われている。

【０００５】

【発明が解決しようとする課題】一般に、薄膜キャパシタの容量を増加させるためには、電極間隔、つまり容量膜である高誘電率膜の膜厚を薄くすることが必要である。特に、１Ｇｂｉｔ以上の次世代高密度ＤＲＡＭを考えた場合においてはＢＳＴなどの高誘電率膜を用いても２０～３０ｎｍ程度の極薄膜化が必要である。しかしながら、このような高誘電率膜の極薄膜化は薄膜キャパシタのリーク電流を増大させるという問題がある。一般に、キャパシタの面積を勘案し、このような薄膜キャパシタのリーク電流密度は、１Ｖ印加時で$1\times10^{-8}Acm^{-2}$以下が必要とされている。

【０００６】従来の薄膜キャパシタにおいては、ＢＳＴの膜厚が２５ｎｍであるとき、１Ｖ印加時でのリーク電流密度は約$4\times10^{-8}Acm^{-2}$であり、要求される電流密度に達していないという問題があった。

【０００７】他方、従来の薄膜キャパシタの製造方法では上部電極Ｒｕの加工の際、Ｒｕ電極の上にSiO_2を成膜し、レジストを塗布して一般的に用いられるフォトリソグラフィ技術によりレジストを加工し、SiO_2をパターニングして、Ｒｕの加工を行っていた。このように、従来の技術では、SiO_2の成膜と除去という工程が入りスループットの点で問題があった。

【０００８】また、Ｒｕを１Ｇｂｉｔ以上の次世代高密度ＤＲＡＭの下部電極に用いる際、Ｒｕを０．１～０．２ミクロンサイズで加工しなければならないが、ＳｉＯ

$_2$ マスクを用いた場合には、上記の理由でスループットの点で問題があると同時に、加工形状に問題があった。これは、SiO_2 が非晶質であり、ＲｕドライエッチングにSiO_2 の肩がエッチングされることによって、SiO_2 マスク面積が小さくなり、加工されたＲｕが垂直に加工しにくいためである。

【０００９】本発明の目的は、リーク電流密度が小さい薄膜キャパシタを提供することにある。また、スループットが高く、低温でのプロセスであるため半導体の回路特性を劣化させることがない薄膜キャパシタの製造方法を提供することにあり、更に、超高密度集積回路の加工が目的の加工形状で達成できる薄膜キャパシタの製造方法及び電極の加工方法を提供することにある。

【００１０】

【課題を解決するための手段】前記の目的は以下の手段によって達成される。すなわち、本発明は、高誘電率薄膜が、下部電極膜、及び単層或は複数層からなる上部電極膜で挟まれた構造の薄膜キャパシタにおいて、該上部電極膜の少なくとも該高誘電率膜に接する第１の電極層がルテニウム（Ｒｕ）、或は酸化ルテニウム（RuO_2）であり、かつ前記電極層の膜厚が５０ｎｍ未満であることを特徴とする薄膜キャパシタを提案するものである。

【００１１】また、本発明は、高誘電率薄膜が、下部電極膜、及び単層或は複数層からなる上部電極膜で挟まれた構造の薄膜キャパシタの製造方法において、該上部電極薄膜の少なくとも該高誘電率膜に接する電極層としてルテニウム（Ｒｕ）、或は酸化ルテニウム（RuO_2）を形成する工程と、該上部電極薄膜の最上層である第２の電極層として、酸素を含む雰囲気でのドライエッチングによりエッチングされないか、或はドライエッチングのエッチング速度が第１の電極層のエッチング速度の１／１０以下である導電性電極材料を形成する工程を少なくとも含むことを特徴とする薄膜キャパシタの製造方法を提案するものであり、前記第２の電極層はアルミニウム（Ａｌ）、チタン（Ｔｉ）、或は窒化チタン（ＴｉＮ）のいずれかであることを含む。

【００１２】また、本発明は、高誘電率膜が、下部電極、及び上部電極で挟まれた構造の薄膜キャパシタの製造方法であり、少なくとも下部電極、或は上部電極にルテニウム（Ｒｕ）、或は酸化ルテニウム（RuO_2）層の酸素を含む雰囲気でのドライエッチングの工程が含まれる製造方法において、該ルテニウム、或は酸化ルテニウムの電極層をドライエッチの工程が、該電極の最表面がアルミニウム（Ａｌ）、チタン（Ｔｉ）、或は窒化チタン（ＴｉＮ）のいずれかで形成された電極構造でのエッチング工程であることを特徴とする薄膜キャパシタの製造方法を提案するものであり、更に本発明は単層或は複数層で構成された電極で、かつ前記電極にルテニウム（Ｒｕ）、或は酸化ルテニウム（RuO_2）の層が含まれ、かつ該ルテニウム（Ｒｕ）、或は該酸化ルテニウム（RuO_2）が酸素を含む雰囲気でのドライエッチング工程を有する電極の加工方法において、前記ドライエッチングの工程が、該電極の最表面がアルミニウム（Ａｌ）、チタン（Ｔｉ）、或は窒化チタン（ＴｉＮ）のいずれかで形成された電極構造でのエッチング工程であることを特徴とする電極の加工方法を提案するものである。

【００１３】

【発明の実施の形態】以下、本発明を更に詳細に説明する。

【００１４】本発明者等は、高誘電率膜としてＢＳＴを用い、上部電極としてＲｕ、及びRuO_2 をそれぞれ用いて薄膜キャパシタを形成し、そのリーク電流特性を調べた。下部電極は白金（Ｐｔ）である。その結果、上部電極の膜厚を１００ｎｍ以下にすることによって、リーク電流が減少することを見出した。同時に、膜厚が５０ｎｍ未満でリーク電流の減少傾向が顕著であることを見出した。上部電極の膜厚が２００ｎｍを基準とすると、膜厚が５０ｎｍで約１／１０に減少し、膜厚が３０ｎｍでは約１／１５に減少した。この理由の詳細は不明であるが、上部電極形成時のＢＳＴ膜へのダメージの減少、ストレスの減少が考えられる。

【００１５】本発明者等は、高誘電率膜としてＢＳＴを用い、ＢＳＴに接する上部電極層としてＲｕ，RuO_2 の上部にＡｌ、Ｔｉ及びＴｉＮをそれぞれ形成した。この上にレジストを塗布し、通常のフォトリソグラフィ技術によりレジストを加工し、それをマスクとしてＲｕ、RuO_2 の上のそれぞれの導電性電極をドライエッチングした。この時、塩素ガスを用いた。続けて、酸素を含む雰囲気でＲｕ、RuO_2 をドライエッチングすると、Ｒｕ、RuO_2 のエッチングとともにレジストもエッチングが進行するが、Ｒｕ、RuO_2 の上の導電性電極はエッチングさせず、Ｒｕ、RuO_2 を加工することができることが分かった。残存したレジストはO_2 アッシングで容易に除去できた。同時に、Ｒｕ、RuO_2 の上の導電性電極はこのまま上部電極として使用可能であり、不要ならばレジスト除去後連続してドライエッチ可能であることも確認した。この手法では、SiO_2 の形成、及び除去の工程は必要なく、非常に簡便でスループットが高いことが明らかとなった。また第２の電極層としてドライエッチングのエッチング速度が第１の電極層のエッチング速度の１／１０以下の電極材料を用いるようにしても第２の電極をエッチングさせることなく、第１電極のＲｕ、RuO_2 を加工することができることが分かった。

【００１６】同様に、特にＲｕ、RuO_2 を超微細に加工する際、Ｒｕ、RuO_2 電極の上面にＡｌ、Ｔｉ或いはＴｉＮを形成し、上記と同様な工程でドライエッチング加工を行ったが、Ａｌ、Ｔｉ或いはＴｉＮはまったく

肩崩れせず、Ｒｕ、RuO_2をほぼ垂直に加工することが可能であった。

【００１７】更に、本発明を図面を参照して説明する。

【００１８】図１は本発明の薄膜キャパシタの一例を示す断面図である。本発明の薄膜キャパシタは図１に示すように、基板表面が熱酸化で形成されたSiO_2 ４を有するシリコン（Ｓｉ）基板５上に高誘電率薄膜２が下部電極３及び上部電極膜１で挟まれた構造を設けてなるものである。

【００１９】高誘電率薄膜２としては$SrTiO_3$、（Ｂａ，Ｓｒ）TiO_3（ＢＳＴ）、$BaTiO_3$、（Ｐｂ，Ｚｒ）TiO_3、$SrBi_2Ta_2O_9$等が挙げられ、厚みは１５～２００ｎｍの範囲が好ましい。

【００２０】上部電極膜１は単層或は複数層からなり、少なくとも高誘電率膜に接する第１の電極層はルテニウム（Ｒｕ）、或は酸化ルテニウム（RuO_2）からなり、かつその膜厚が５０ｎｍ未満５ｎｍ以上であることが特に肝要である。

【００２１】膜厚が５０ｎｍを越えると薄膜キャパシタのリーク電流を増大させるので好ましくなく、５ｎｍ未満では均一膜が得られにくい（面内での局所的不連続の）問題があり好ましくない。また上部電極膜１が複数層からなる場合は第２の電極膜としては、アルミニウム（Ａｌ）、チタン（Ｔｉ）或は窒化チタン（ＴｉＮ）が好ましく用いられる。

【００２２】また下部電極３としてＰｔ、Ｒｕ、RuO_2、Ｉｒ、IrO_2等が挙げられ、厚みは５～５００ｎｍの範囲が好ましい。

【００２３】前記の膜はいずれもＤＣマグネトロンスパッタ法、ＲＦマグネトロンスパッタ法、ＥＣＲスパッタ法、気相成長法等の方法で成膜可能である。

【００２４】

【実施例】以下本発明を実施例により更に具体的に説明する。

【００２５】（実施例１）以下、本発明の実施例について、図１を参照しながら説明する。図１は実施例１に関わる薄膜キャパシタの断面図である。高誘電率膜２としてＢＳＴを用い、基板表面が熱酸化で形成されたSiO_2 ４を有するシリコン（Ｓｉ）基板５上に、下部電極３としてＰｔ、高誘電率膜２、上部電極として単層のＲｕが３０ｎｍ形成された構造となっている。この実施例では、ＢＳＴ膜厚は３０ｎｍであり、すべての膜はＤＣマグネトロンスパッタリング法によって形成した。上部電極の形状は、０．２ｍｍφの円形である。電気特性を測定した結果、誘電率は、２９０であり、リーク電流密度Ｊは$8\times10^{-9}Acm^{-2}$であった。本発明のＲｕの薄膜化の効果を調べるため、同じ試料に対し上部電極であるＲｕの膜厚を２００ｎｍまで変化させて調べた結果、２００ｎｍでＪは$8\times10^{-8}Acm^{-2}$、１００ｎｍで$1.5\times10^{-8}Acm^{-2}$であり、本発明の効果が確認された。誘電率は、上部電極の膜厚によらず一定であった。

【００２６】（実施例２）実施例１と同様に、高誘電率膜２としてＢＳＴを用い、基板表面が熱酸化で形成されたSiO_2 ４を有するシリコン（Ｓｉ）基板５上に、下部電極３としてＰｔ、高誘電率膜２、上部電極としてＲｕ（３０ｎｍ）、Ａｌ（１００ｎｍ）が下から順に積層された電極である構造となっている。この実施例では、ＢＳＴ膜厚は３０ｎｍであり、すべての膜はＤＣマグネトロンスパッタリング法によって形成した。上部電極の形状は、０．２ｍｍφの円形である。電気特性を測定した結果、誘電率は、２９０であり、リーク電流密度Ｊは$8\times10^{-9}Acm^{-2}$であった。本発明の効果を調べるため、実施例１で行ったことと同様に、上部電極層のＡｌの膜厚を一定として、Ｒｕの薄膜化の効果を調べた。結果は、実施例１とまったく同一であり、本発明の効果が確認された。

【００２７】（実施例３）本実施例では、下部電極３としてRuO_2、高誘電率膜２としてＢＳＴ、上部電極１の第１の電極層としてＲｕ、第２の電極層としてＴｉＮを用いた例について、図２を参照しながら説明する。

【００２８】基板表面が熱酸化で形成されたSiO_2 ４を有するシリコン（Ｓｉ）基板５上に、下部電極３（RuO_2）、高誘電率膜２（ＢＳＴ）、上部電極１の第１の電極層６（Ｒｕ）、第２の電極層７（ＴｉＮ）を順次ＤＣマグネトロンスパッタ法で成膜した。膜厚は、下部電極が２００ｎｍ、ＢＳＴは３０ｎｍ、第１の電極層が３０ｎｍ、第２の電極層が７０ｎｍとした。続けて、レジスト８を塗布し、図２（ａ）に示す基板を得た。レジストを通常のｉ線によるリソグラフィ技術により露光、加工し、図２（ｂ）を形成した。この基板をドライエッチング装置に入れ、まず、第２の電極層７であるＴｉＮをCl_2プラズマガスによりエッチングした。この時、エッチング装置のチャンバ圧力は１５ｍＴｏｒｒ、プラズマパワーは５０Ｗであった。続けて、第１の電極層６であるＲｕをO_2とCl_2の混合ガス（Cl_2が１０％）を用いてエッチングした。この時のチャンバ圧力は２０ｍＴｏｒｒ、プラズマパワーは１００Ｗである。Ｒｕをドライエッチング中にレジストはほとんど消失したが、残存したレジストを除去するため、酸素プラズマによるアッシングにより除去した。その結果、図２（ｃ）に示すような上部電極が加工された薄膜キャパシタが得られた。同様に、第２の電極層として、Ａｌ、或はＴｉを用いて同様な製造方法で検討したが、まったく同様な薄膜キャパシタが得られた。このキャパシタの電気特性は、実施例１、２と同様な良好な特性を示した。

【００２９】この工程では、マスクとしてSiO_2を形成しておらず、本発明の効果が確認された。

【００３０】上記実施例では、第２の電極層を除去せず、電極としてそのまま使用したが、レジストをアッシング除去した後、Cl_2のプラズマガスによるドライエ

ッチングにより第２の電極層７（ＴｉＮ）を除去した薄膜キャパシタも制作したが、除去しない場合と電気的特性は同一であった。

【００３１】（実施例４）本実施例では、下部電極であるＲｕを極微細加工した例について図３を用いて説明する。

【００３２】基板表面が熱酸化で形成されたSiO_2 ４を有するシリコン（Ｓｉ）基板５上に、Ｒｕ９を３００ｎｍ、ＴｉＮ１０を１００ｎｍ、ＤＣマグネトロンスパッタ法により成膜した。この基板に化学増幅レジスト８を塗布し、図３（ａ）なる基板を形成した。電子ビーム露光により、加工寸法０．２ミクロン×０．５ミクロンのパターンを形成し、レジスト８を加工し、図３（ｂ）なる基板を形成した。この基板をドライエッチング装置に入れ、レジスト８をマスクとして、ＴｉＮ１０をCl_2 プラズマによるエッチングを行った。この時のエッチング装置の圧力は１５ｍＴｏｒｒ、プラズマパワーは５０Ｗである。続けて、Ｒｕ９をO_2 とCl_2 の混合ガス（Cl_2 が１０%）を用いてエッチングした。この時のチャンバ圧力は２０ｍＴｏｒｒ、プラズマパワーは１００Ｗである。Ｒｕをドライエッチング中にレジストは消失した。続けて、ＴｉＮ１０をCl_2 プラズマエッチングし除去し、図３（ｃ）に示す基板を得た。この時のエッチング装置の圧力は１５ｍＴｏｒｒ、プラズマパワーは５０Ｗである。

【００３３】得られた基板を電子顕微鏡で観察した結果、設計寸法通りに加工がなされていることを確認した。また、ＴｉＮの変わりにＴｉ、或はＡｌを用いた場合についても実験を行ったが、同一の結果を得た。

【００３４】上記実施例では、高誘電率膜としてＢＳＴを用いたが、本発明はこの材料に限定されずチタン酸ストロンチウム（$SrTiO_3$）、チタン酸バリウム（$BaTiO_3$）、（Ｐｂ，Ｚｒ）TiO_3 や$SrBi_2Ta_2O_9$ など他の高誘電体膜でも良い。

【００３５】上記実施例では、電極及び誘電体の成膜方法としてＤＣマグネトロンスパッタ法を用いたが、本発明はこれに限定されず、ＲＦマグネトロンスパッタ法、ＥＣＲスパッタ法、や気相成長法でも良い。

【００３６】上記実施例では、Ｒｕを用いたが、本発明はこの材料に限定されず、RuO_2でも良い。

【００３７】

【発明の効果】以上、説明したように、本発明の薄膜キャパシタによれば、リーク電流密度が小さく、電気的特性に優れるという効果がある。また、本発明の薄膜キャパシタの製造方法によれば、スループットが高く、低温でのプロセスであるため半導体の回路特性を劣化させることがない、更に、超高密度集積回路の加工が目的の加工形状で達成できるという効果がある。

【図面の簡単な説明】

【図１】本発明の一実施例を示す薄膜キャパシタの断面図である。

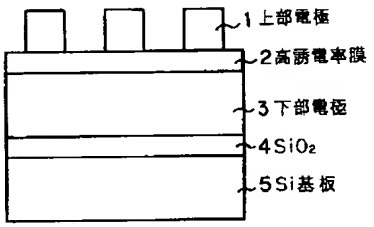
【図２】図２（ａ）～（ｃ）は本発明の一実施例を示す薄膜キャパシタの製造工程図である。

【図３】図３（ａ）～（ｃ）は本発明の一実施例を示す薄膜キャパシタの製造工程図である。

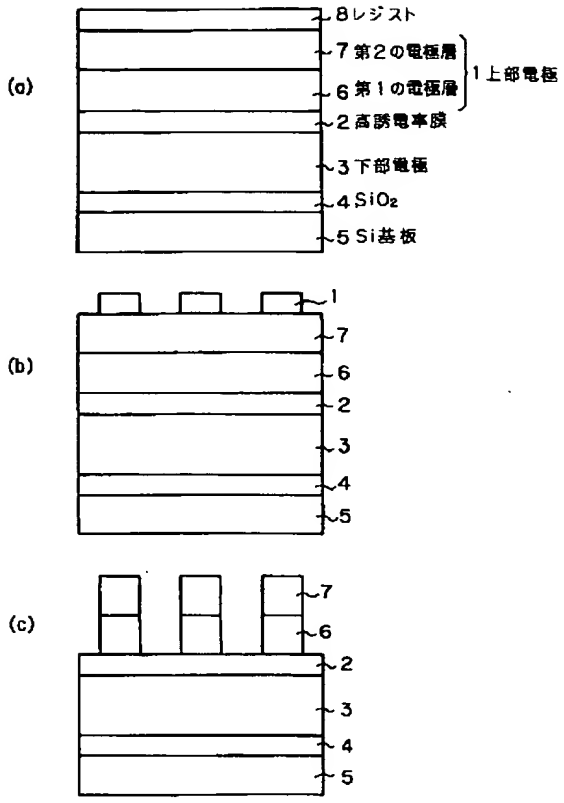
【符号の説明】

１	上部電極
２	高誘電率膜
３	下部電極
４	SiO_2
５	Ｓｉ基板
６	第１の電極層
７	第２の電極層
８	レジスト
９	Ｒｕ
１０	ＴｉＮ

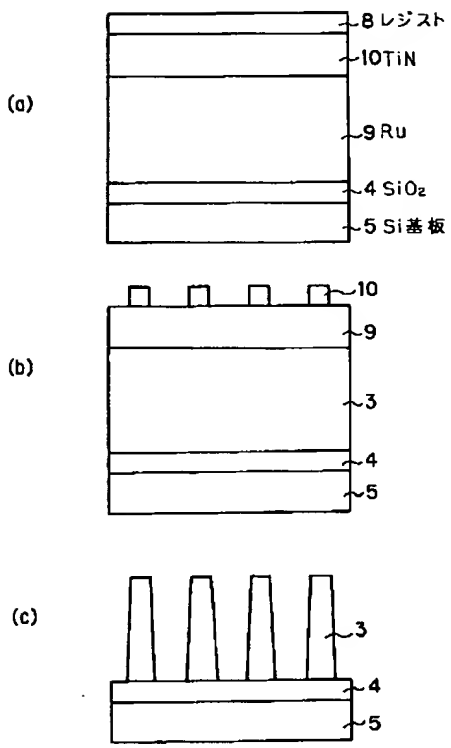
【図１】



【図２】



【図３】



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